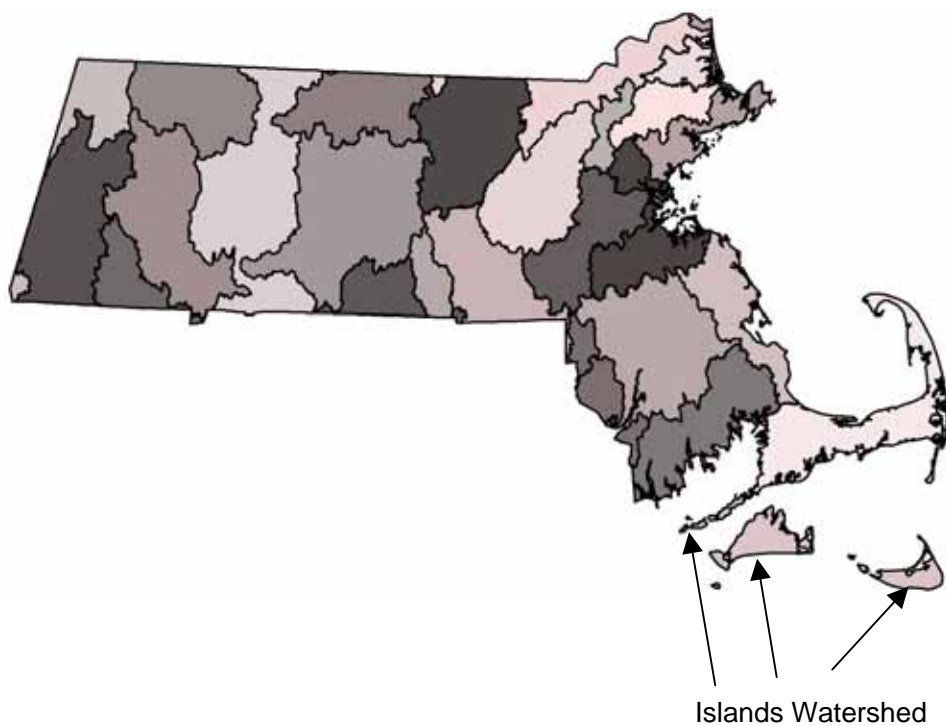


Draft Pathogen TMDL for the Islands Watershed



Prepared as a cooperative effort by:

Massachusetts DEP
1 Winter Street
Boston, Massachusetts 02108

USEPA New England Region 1
1 Congress Street, Suite 1100
Boston, Massachusetts 02114



ENSR International
2 Technology Park Drive
Westford, MA 01886

NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

This report is also available from MADEP's home page on the World Wide Web.

A complete list of reports published since 1963 is updated annually and printed in July. This list, titled "Publications of the Massachusetts Division of Watershed Management (DWM) – Watershed Planning Program, 1963-(current year)", is also available by writing to the DWM in Worcester.

DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement

This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the Islands Watershed



Key Features:	Pathogen TMDL for the Islands Watershed
Location:	EPA Region 1
Land Type:	New England Coastal
303(d) Listings:	Pathogens Nantucket: Nantucket Harbor (MA97-01); Polpis Harbor (MA97-26); and Sesachacha Pond (MA97-02). Martha's Vineyard: Chilmark Pond (MA97-05); Edgartown Great Pond (MA97-17); Edgartown Harbor (MA97-15); Menemsha Pond (MA97-06); Oak Bluffs Harbor (MA97-07); Oyster Pond (MA97-13); Sengekontacket Pond (MA97-10); Tisbury Great Pond (MA97-18); and Vineyard Haven Harbor (MA97-09). Elizabeth Islands: Cuttyhunk Pond (MA97-21); and Westend Pond (MA97-20).
Data Sources:	MADEP 2003. Islands Watershed 2000 Water Quality Assessment Report.
Data Mechanism:	Massachusetts Surface Water Quality Standards for Fecal Coliform; The Federal BEACH Act; Massachusetts Department of Public Health Bathing Beaches; Massachusetts Division of Marine Fisheries Shellfish Sanitation and Management; Massachusetts Coastal Zone Management
Monitoring Plan:	Massachusetts Watershed Five-Year Cycle
Control Measures:	Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); SSO Abatement; BMPs; By-laws; Ordinances; No Discharge Areas; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

- a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;
- b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;
- c) harbormasters, public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach and/or shellfish closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;
- d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a “pollution budget” designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Islands watershed. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Islands watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Islands watershed including failing septic systems, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: *“Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts”*.

This TMDL applies to the 14 pathogen impaired segments of the Islands watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Islands watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) "Section VII Funding / Community Resources". This document is available on the MADEP's website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP's Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Islands Watershed

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
SA, B	Illicit discharges to storm drains	0	N/A
SA, B	Leaking sanitary sewer lines	0	N/A
SA, B	Failing septic systems	N/A	0
B & Not Designated for Shellfishing SA	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ²	N/A
B & Not Designated for Shellfishing SA	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³	N/A
B & Not Designated for Shellfishing SA	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ²	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches ⁴	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) ¹	Load Allocation Indicator Bacteria (CFU/100 mL) ¹
Fresh Water Beaches ⁵	All Sources	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>

N/A means not applicable

¹ Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

² Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

³The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

⁴ Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

⁵ Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

Table of Contents

EXECUTIVE SUMMARY	III
Purpose and Intended Audience	iii
TMDL Overview	iii
1.0 INTRODUCTION	1
1.1. Pathogens and Indicator Bacteria	3
1.2. Comprehensive Watershed-based Approach to TMDL Development.....	4
1.3. TMDL Report Format	6
2.0 WATERSHED DESCRIPTION	7
3.0 WATER QUALITY STANDARDS	12
4.0 PROBLEM ASSESSMENT	16
4.1. Nantucket.....	21
4.2. Martha's Vineyard	21
4.3. The Elizabeth (Gosnold) Islands	23
5.0 POTENTIAL SOURCES	25
6.0 PATHOGEN TMDL DEVELOPMENT	30
6.1. Indicator Bacteria TMDL	30
6.2. Margin of Safety	35
6.3. Seasonal Variability	35
7.0 IMPLEMENTATION PLAN	36
7.1. Summary of Activities within the Islands Watershed	38
7.2. Illicit Sewer Connections and Failing Infrastructure	39

7.3. Storm Water Runoff	40
7.4. Failing Septic Systems.....	40
7.5. Wastewater Treatment Plants.....	41
7.6. Recreational Waters Use Management	41
7.7. Funding/Community Resources.....	41
7.8. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts	42
8.0 MONITORING PLAN	43
9.0 REASONABLE ASSURANCES	43
10.0 PUBLIC PARTICIPATION	43
11.0 REFERENCES	44
 Appendix A Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol Guidance for Consideration - November 2004	

List of Tables

Table ES-1.	Sources and Expectations for Limiting Bacterial Contamination in the Islands Watershed	vi
Table 2-1.	Islands Watershed Land Use as of 1999.	8
Table 4-1.	Wachusett Reservoir Storm Water Sampling.	17
Table 4-2.	Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations	17
Table 4-3.	Islands Watershed Pathogen Impaired Segments Requiring TMDLs	19
Table 5-1.	Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Islands Watershed.	26
Table 5-2.	Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations and Necessary Reductions to Meet Class B WQS.	29
Table 5-3.	Storm Water Event Mean Fecal Coliform Concentrations and Necessary Reductions to Meet Class B WQS.	29
Table 6-1.	Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Islands Watershed.	33
Table 7-1.	Tasks	37

List of Figures

Figure 1-1.	Islands Watershed and Pathogen Impaired Segments.....	2
Figure 1-2.	Relationships among Indicator Organisms.	4
Figure 2-1.	Islands Watershed Land Use as of 1999.	9
Figure 2-2.	Islands Marine Beach Locations and Pathogen Impaired Segments.....	10
Figure 2-3.	General Location of Massachusetts' No Discharge Areas.....	11

1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (2002 List; MADEP 2003a). Figure 1-1 provides a map of the Islands watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Islands waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Islands waterbodies. These include shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local

Figure 1-1. Islands Watershed and Pathogen Impaired Segments

problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

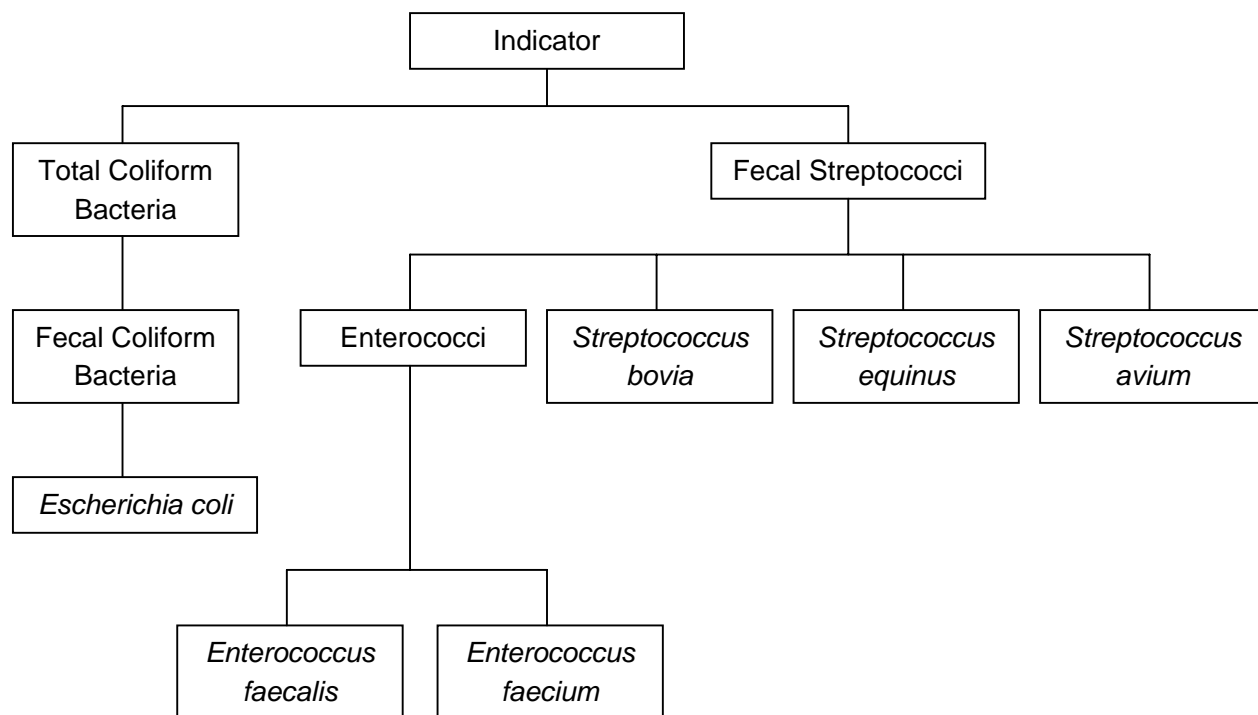
The Islands watershed pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli*. Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The Islands watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh and marine waters and enterococci for marine beaches. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Islands watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Islands watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 14 pathogen impaired segments of the Islands watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the *“Islands Watershed 2000 Water Quality Assessment Report”* (MADEP WQA; MADEP 2003a) (see Figure 1-1, Table 4-3). MADEP recommends however, that the

information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Islands watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 25 waterbody segments assessed by the MADEP in the Islands watershed (MassGIS 2005). These segments consist of twenty-one estuary segments, fourteen of which are pathogen impaired, and four lake segments, none of which are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). Pathogen impairment has been documented by the MADEP in previous reports, including the “*Islands Watershed 2000 Water Quality Assessment Report*” (WQA; MADEP 2003a), resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the Islands watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) - provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Islands watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Islands watershed
- TMDL Development (Section 6) – specifies required TMDL development components including:
 - Definitions and Equation
 - Loading Capacity
 - Load and Waste Load Allocations
 - Margin of Safety
 - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” document should be used together to support implementing management actions
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process
- References (Section 11)

2.0 Watershed Description

The Islands watershed includes the Nantucket, Martha's Vineyard, and Elizabeth (Gosnold) Islands. Roughly 75% of the land use on the islands is devoted to open space and natural areas. Residential and commercial/industrial areas make up the remaining 25% of land use (Table 2-1). Dukes and Nantucket counties make up the land area of the watershed. It is also important to note that the populations of Dukes and Nantucket counties have had the highest percent change in population of all Massachusetts counties between 1990 and 2000, 29% and 58% increases respectively (Cape Cod Times 2001). The islands also both experience extreme increases in population during the summer months. The population on Martha's Vineyard can increase from a resident population of 14,000 during the winter months to 100,000 during the tourist season (EOEA 2003a). On Nantucket the population increases from 8,520 to 40,000 (EOEA 2003b).

Nantucket is approximately 49 square miles and has roughly 94 miles of shoreline. The geology of Nantucket is characterized by moraines and outwash planes. The maximum elevation of the island is approximately 100 feet above sea level. The open space on Nantucket is dominated by open land, pasture, and cropland (Figure 2-1).

Martha's Vineyard is a 96 square mile island with roughly 125 miles of shoreline. The island is divided into six towns: Chilmark, Edgartown, Gay Head, Oak Bluffs, Tisbury, and West Tisbury. "Maximum elevation on the Island is approximately 300 feet" (MADEP 2003a). Martha's Vineyard includes extensive areas of woody perennial forest and residential developments (Figure 2-1).

"The Elizabeth Islands are a chain of fifteen islands encompassing 13.6 square miles with approximately 54 miles of tidal shoreline in the town of Gosnold, Dukes County" (MADEP 2003a). The Elizabeth Islands contain extensive areas of open space and isolated areas of residential land use (Figure 2-1).

Nantucket Harbor is considered a "No Discharge Area" (NDA). NDAs are waterbodies in which a state, with EPA approval, has determined to be important ecological or recreational areas worthy of special protection against the release of raw or treated sewage in navigable waters. Vessels are banned from discharging both raw and treated sewage in a NDA. NDAs in Massachusetts are provided in Figure 2-3 (USEPA 2004a).

Groundwater supplies drinking water resources on all the islands. Under the Safe Drinking Water Act, Martha's Vineyard and Nantucket have been declared sole source aquifers by the EPA. "The designation protects an area's ground water resource by requiring U.S Environmental Protection Agency (EPA) review of any proposed projects within the designated area that are receiving federal financial assistance. All proposed projects receiving federal funds are subject to review to ensure they do not endanger the water source" (USEPA 2005).

The Islands watershed also encompasses extensive marine and brackish resources used for recreation, bathing beaches, boating, swimming and shellfish harvesting. Figure 2-2 shows the marine beach locations on the islands. The Islands watershed waters are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, shellfish harvesting, irrigation, agricultural uses, public water supply, and beachfront. Information regarding swimming beaches can be obtained from the beach quality annual reports available for download at the Massachusetts Department of Public Health website (<http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>).

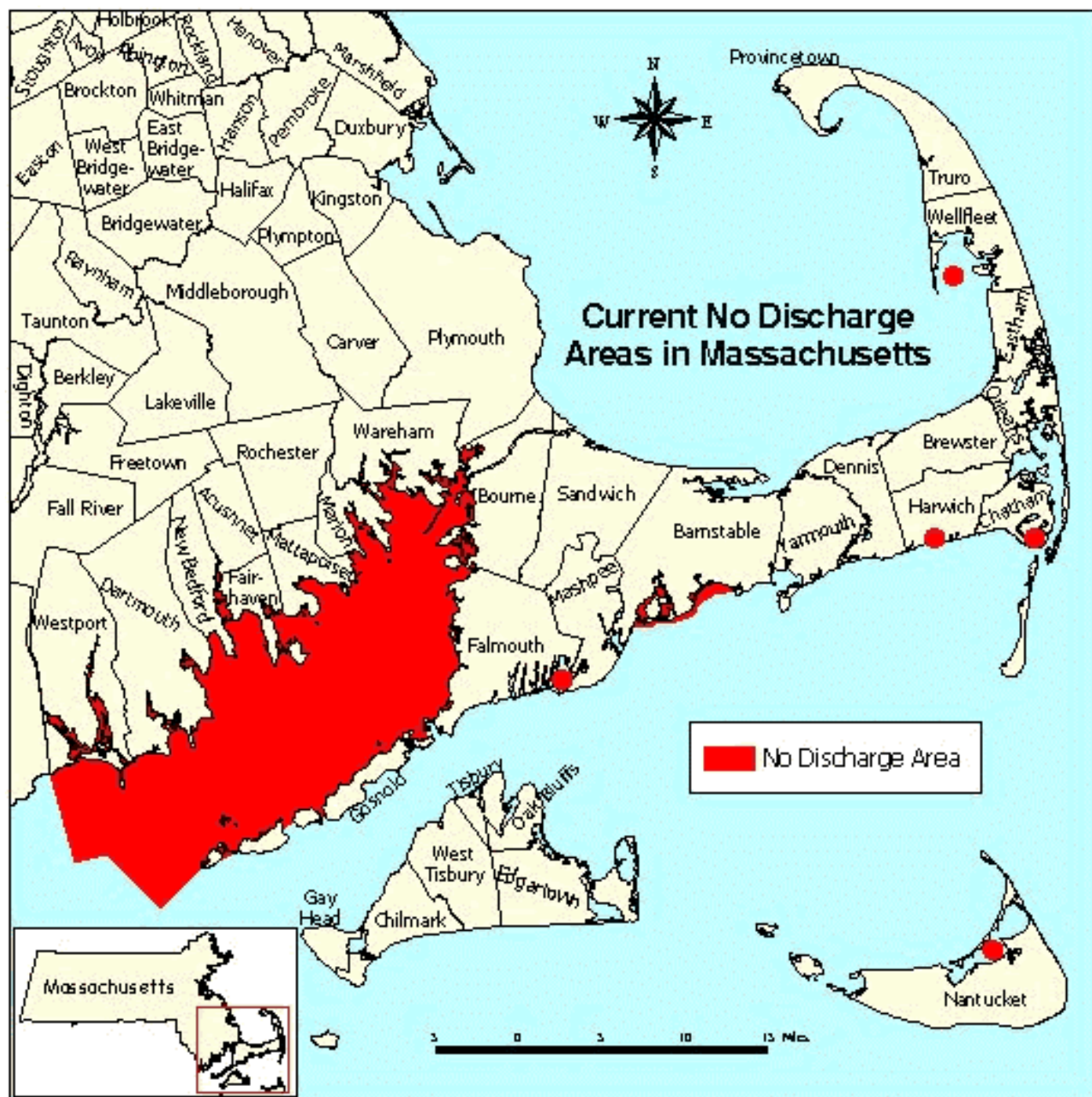
Table 2-1. Islands Watershed Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	1.8
Urban Open	0.5
Open Land	28.8
Cropland	1.8
Woody Perennial	0.6
Forest	35.9
Wetland/Salt Wetland	1.0
Water Based Recreation	<0.1
Water	5.0
General Undeveloped Land	75.5
Spectator Recreation	2.4
Participation Recreation	1.0
> 1/2 acre lots Residential	2.0
1/4 - 1/2 acre lots Residential	13.1
< 1/4 acre lots Residential	3.3
Multi-family Residential	1.0
Mining	0.2
Commercial	0.3
Industrial	0.1
Transportation	1.0
Waste Disposal	0.2
General Developed Land	24.5

Figure 2-1. Islands Watershed Land Use as of 1999.

Figure 2-2. Islands Marine Beach Locations and Pathogen Impaired Segments.

Figure 2-3. General Location of Massachusetts' No Discharge Areas (USEPA 2004a).



3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. “Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems” (USEPA 2004b). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Islands watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh and marine waters and enterococci for marine beaches, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
<http://www.epa.gov/ost/humanhealth/microbial/microbial.html>
- Human Health Advisories:
 - Fish and Wildlife Consumption Advisories
<http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html>

- Swimming Advisories
<http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html>

The Islands watershed contains waterbodies classified as Class SA and B. The corresponding WQS for Class SA and B are as follows:

Class B and Class SA not designated for shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis for waters classified as Class B, and Class SA not designated for shellfishing.

Class SA waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL and no more than 10% of the samples shall exceed 43 organisms per 100 mL.

Shellfish growing areas are classified by the Massachusetts Division of Marine Fisheries (DMF). The classification system is provided below. Figure 1-1 provides designated shellfish growing areas status as of July 1, 2000.

Approved – “Open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “The area is shown to be free of bacterial contaminants under a variety of climatological and hydrographical situations (i.e. assumed adverse pollution conditions).” (MADEP 2002a)

Conditionally Approved - “During the time area is approved it is open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “This classification category may be assigned for growing areas subject to intermittent and predictable microbiological contamination that may be present due to operation of a sewage treatment plant, rainfall, and/or season.” (MADEP 2002a)

Conditionally Restricted – “During the time area is restricted it is only open for the harvest of shellfish with depuration subject to local rules and state regulations.” (MassGIS 2005) “A classification used to identify a growing area that meets the criteria for the restricted classification except under certain conditions described in a management plan.” (MADEP 2002a)

Restricted – “Open for harvest of shellfish with depuration subject to local rules and state regulations or for the relay of shellfish.” (MassGIS 2005) “A classification used to identify where harvesting shall be by special license and the shellstock, following harvest, is subject to a suitable and effective treatment process through relaying or depuration. Restricted growing areas are mildly or moderately contaminated only with bacteria.” (MADEP 2002a)

Management Closure – “Closed for the harvest of shellfish. Not enough testing has been done in the area to determine whether it is fit for shellfish harvest or not.” (MADEP 2002a)

Prohibited – “Closed for harvest of shellfish.” (MassGIS 2005) “A classification used to identify a growing area where the harvest of shellstock is not permitted. Growing area waters are so badly contaminated that no reasonable amount of treatment will make the shellfish safe for human consumption. Growing areas must also be classified as Prohibited if there is no or insufficient information available to make a classification decision.” (MADEP 2002a)

In general, shellfish harvesting use is supported (i.e., non-impaired) when shellfish harvested from approved open shellfish areas are suitable for consumption without depuration and shellfish harvested from restricted shellfish areas are suitable for consumption with depuration. For an expanded discussion on the relationship between the DMF shellfish growing areas classification and the MADEP designated use support status, please see the “*Islands Watershed 2000 Water Quality Assessment Report*” (MADEP WQA; MADEP 2003a).

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at <http://www.epa.gov/waterscience/beaches/act.html> and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

Figure 2-2 provides the location of marine bathing beaches, where the MADPH Marine Waters and the Federal BEACH Act standards would apply. A map of freshwater beaches is not available at this time. However, a list of beaches (fresh and marine) by community with indicator bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at <http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the Islands watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli*, etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates.

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1. Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002b) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria¹ Organisms / 100 mL
Agriculture, Storm 1	110 - 21,200
Agriculture, Storm 2	200 - 56,400
“Pristine” (not developed, forest), Storm 1	0 - 51
“Pristine” (not developed, forest), Storm 2	8 - 766
High Density Residential (not sewered, on septic systems), Storm 1	30 - 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 - 122,000

¹ Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002).¹

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

¹ An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired estuary segments represent 72% of the total estuary area assessed (17.3 square miles of 24.0 total square miles). In total, 14 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class SA or B waterbodies (314 CMR 4.05)¹, the MADPH standard for bathing beaches², and/or the BEACH Act³. The basis for impairment listings is provided in the *2002 List* (MADEP 2003b). Data collected by the MADEP were used to generate the *2002 List*. For more information regarding the basis for listing particular segments for pathogen impairment, please see the Assessment Methodology section of the MADEP WQA for this watershed.

A list of pathogen impaired segments requiring is provided in Table 4-3. Brief descriptions of each impaired segment are provided below. Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA.

An overview of the Islands watershed pathogen impairment segments is provided in this section. Indicator bacteria data were not provided in the MADEP WQA for the impaired segments and are therefore not presented in this TMDL. Since pathogen impairment has been previously established and documented on the 2002 List, it is not necessary to provide detailed documentation of pathogen impairment herein.

¹ Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.

Class SA (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 14 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 43 organisms per 100 mL.

Class SB (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 88 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 260 organisms per 100 mL.

Class B, Class SA & Class SB (waters not designated for shellfishing): Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

² Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

³ BEACH Act - Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Table 4-3. Islands Watershed Pathogen Impaired Segments Requiring TMDLs (adapted from MADEP 2003a and Mass GIS 2005).

Segment ID	Segment Name	Segment Type	Segment Size (mi ²)	Segment Description
Nantucket				
MA97-01	Nantucket Harbor	Estuary	7.16	From Head of the Harbor to an imaginary line drawn from Jetties Beach to Coatue Point (excluding Polpis Harbor and Coskata Pond)
MA97-26	Polpis Harbor	Estuary	0.30	Polpis Harbor and all adjacent coves to a line from Quaise Point to the opposite shore
MA97-02	Sesachacha Pond	Estuary	0.42	South of Quidnet Road and North of Polpis Road
Martha's Vineyard				
MA97-09	Vineyard Haven Harbor	Estuary	1.5	From confluence with Lagoon Pond at Beach Road to an imaginary line drawn from West Chop Light, Tisbury to East Chop Light, Oak Bluffs, Tisbury/Oak Bluffs
MA97-07	Oak Bluffs Harbor	Estuary	0.05	North of Lake Avenue to confluence with Nantucket Sound, Oak Bluffs
MA97-10	Sengekontacket Pond	Estuary	1.1	Between East Vineyard Haven Road and Beach Road, including Major's Cove, Edgartown/Oak Bluffs
MA97-15	Edgartown Harbor	Estuary	3.1	Waters from Cape Poge Gut and from an imaginary line drawn from Dock Street to Chappaquiddick Point to a line drawn northeast from the point at the end of Plantingfield Way to Cape Poge Elbow (excluding Eel Pond), Edgartown
MA97-17	Edgartown Great Pond	Estuary	1.4	Including Jobs Neck Cove, Jane's Cove, Wintucket Cove, Mashacket Cove, Turkeyland Cove, Slough Cove, and Butler's Cove, Edgartown
MA97-13	Oyster Pond	Estuary	0.31	Including Ripley Cove, Edgartown
MA97-18	Tisbury Great Pond	Estuary	1.1	Including Town Cove, Muddy Cove, Pear Tree Cove, Short Cove, Tiah Cove, Tississa Pond, Deep Bottom Cove, and Thumb Cove, Chimark/West Tisbury
MA97-05	Chilmark Pond	Estuary	0.31	South of South Road including Wades Cove and Gilberts Cove, Chilmark
MA97-06	Menemsha Pond	Estuary	0.89	From mouth of Menemsha Creek to confluence with Nashaquitsa Pond, Gay Head
Elizabeth (Gosnold) Islands				
MA97-20	Westend Pond	Estuary	0.10	Cuttyhunk Island, Gosnold
MA97-21	Cuttyhunk Pond	Estuary	0.15	Waters to the western extent of the channel connecting Cuttyhunk Pond to Cuttyhunk Harbor, Gosnold (Changed from MA95-26 to MA97-21 on 10/7/97)

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh and marine waters and enterococci for marine beaches. Enterococci data are provided at the bottom of each table when data are available. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the *2002 List*. Other data presented in this section are for illustrative purposes only.

Data from the Massachusetts Division of Marine Fisheries (DMF) were used, in part, as the basis for pathogen impairment for many of the estuarine areas (Figure 1-1). Numerous samples have been collected throughout the Islands watershed by the DMF. DMF has a well-established and effective shellfish monitoring program that provides quality assured data for each shellfish growing area. In addition, each growing area must have a complete sanitary survey every 12 years, a triennial evaluation every three years and an annual review in order to maintain a shellfishing harvesting classification with the exception of those areas already classified as Prohibited. The National Shellfish Sanitation Program establishes minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring and includes identification of specific sources and assessment of effectiveness of controls and attainment of standards. "Each year water samples are collected by the DMF at 2,320 stations in 294 growing areas in Massachusetts's coastal waters at a minimum frequency of five times while open to harvesting" (DMF 2002). Due to the volume of data collected by the DMF, these data are not provided herein. For the most recent indicator bacteria sampling data, please contact your local city or town shellfish constable or DMF's Shellfish Project.

Segment descriptions in the following subsections can be found at:

- **MADEP WQA 2003a** - Islands Watershed 2000 Water Quality Assessment Report. Available for download at: <http://www.mass.gov/dep/brp/wm/wqassess.htm>.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from <http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

The purpose of this section of the report is to briefly describe the impaired waterbody segments in the Islands watershed. For more information on any of these segments, see the "*Islands Watershed 2000 Water Quality Assessment Report*" on the MADEP website: <http://www.mass.gov/dep/brp/wm/wqassess.htm>.

4.1. Nantucket

Three impaired segments are located on Nantucket Island. All impaired segments are tidal estuaries.

Nantucket Harbor Segment MA97-01

This segment is a 7.16 mi² Class SA tidal estuary located on the northwestern coast of Nantucket. The segment extends from the Head of the Harbor to a line drawn from Jetties Beach to Coatue Point (excluding Polpis Harbor and Coskata Pond), Nantucket. The MADEP WQA lists no discharges for this segment. This segment is a Federal “No Discharge Area”. The dumping of treated or untreated sewage is prohibited. Two water withdrawals are listed in the MADEP WQA for this segment: the Wannacomet Water Company and Nantucket Conservation Foundation. In addition, there are 91.4 acres of cranberry bog in the recharge area of this segment that are estimated to withdraw 0.82 million gallons per day (MGD).

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Conditionally Approved for 7.0 mi² ; Prohibited for 0.15 mi² (Figure 1-1).

Polpis Harbor Segment MA97-26

This segment is a 0.30 mi² Class SA tidal estuary located on the southeastern edge of Nantucket Harbor. The Polpis Harbor segment includes all adjacent coves and extends to a line drawn from Quaise Point to the opposite shore. The MADEP WQA lists no discharges or water withdrawals for this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved for 0.26 mi² ; Prohibited for 0.04 mi² (Figure 1-1).

Sesachacha Pond Segment MA97-02

This segment is a 0.42 mi² Class SA tidal estuary located on the northeastern coast of Martha's Vineyard. The MADEP WQA lists no discharges or permitted water withdrawals for this segment. However, the 4.59 acres of cranberry bogs in the recharge area are estimated to withdraw 0.04 MGD.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Prohibited (Figure 1-1).

4.2. Martha's Vineyard

Nine impaired segments are located on Martha's Vineyard. All impaired segments are tidal estuaries.

Vineyard Haven Harbor Segment MA97-09

This segment is a 1.5 mi² Class SA tidal estuary located on the northern coast of Martha's Vineyard. The MADEP WQA lists no discharges or water withdrawals for this segment. A free boat pumpout area is located in the harbor, funded by Clean Vessel Act.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Conditionally Approved (Figure 1-1).

Oak Bluffs Harbor Segment MA97-07

This segment is a 0.05 mi² Class SA tidal estuary located on the northern coast of Martha's Vineyard. The segment extends from north of Lake Avenue to the confluence with Nantucket Sound in Oaks Bluff. The MADEP WQA lists no discharges or water withdrawals for this segment. The Oak Bluffs Harbor Marina operates a free boat pumpout area, funded by the Clean Vessel Act.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Conditionally Approved (Figure 1-1).

Sengekontacket Pond Segment MA97-10

This segment is a 1.1 mi² Class SA tidal estuary located on the northeastern coast of Martha's Vineyard. Sengekontacket Pond is located between East Vineyard Haven Road and Beach Road in Edgartown/Oak Bluffs. The segment includes Major's Cove. The MADEP WQA lists no discharges for this segment. The MADEP WQA lists two water withdrawals on this segment: Edgartown Water Department and Farm Neck Golf Club. The Town of Edgartown operates a free boat pumpout area, funded by the Clean Vessel Act.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved (Figure 1-1).

Edgartown Harbor Segment MA97-15

This segment is a 3.1 mi² Class SA tidal estuary located on the eastern end of Martha's Vineyard. The segment is the waters from Cape Poge Gut and from an imaginary line drawn from Dock Street to Chappaquiddick Point to an imaginary line drawn northeast from the point at the end of Plantingfield Way to Cape Poge Elbow (excluding Eel Pond), Edgartown. The MADEP WQA lists no discharges or water withdrawals for this segment. The Town of Edgartown operates a free boat pumpout area, funded by the Clean Vessel Act.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved for 3.0 mi²; Conditionally Approved for 0.1 mi² (Figure 1-1).

Edgartown Great Pond Segment MA97-17

This segment is a 1.4 mi² Class SA tidal estuary located on the southern coast of Martha's Vineyard. The MADEP WQA lists two permitted water withdrawals for this segment: the Edgartown Water Department and the Vineyard Golf Club. One groundwater discharge is listed. The Edgartown Wastewater Treatment Facility discharges between 6,000 and 23,000 gallons per day (GPD).

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Conditionally Approved (Figure 1-1).

Oyster Pond Segment MA97-13

This segment is a 0.31 mi² Class SA tidal estuary located on the southern coast of Martha's Vineyard. The segment includes Ripley Cove. The MADEP WQA lists no discharges or water withdrawals for this segment. The Town of Edgartown operates a free boat pumpout area, funded by the Clean Vessel Act.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of February 2003: Under Management Closure (Figure 1-1).

Tisbury Great Pond Segment MA97-18

This segment is a 1.1 mi² Class SA tidal estuary located on the southern coast of Martha's Vineyard in Chilmark/West Tisbury. The segment includes Town Cove, Muddy Cove, Pear Tree Cove, Short Cove, Tiah Cove, Tississa Pond, Deep Bottom Cove, and Thumb Cove. The MADEP WQA lists no discharges or water withdrawals for this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved (Figure 1-1).

Approved for 0.8 mi²; Conditionally Approved for 0.2 mi²; Prohibited for 0.1 mi² (Figure 1-1).

Chilmark Pond Segment MA97-05

This segment is a 0.31 mi² Class SA tidal estuary located on the southern coast of Martha's Vineyard. This segment is located south of South Road and includes Wades Cove and Gilberts Cove, Chilmark. The MADEP WQA lists no discharges or water withdrawals for this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Prohibited (Figure 1-1).

Menemsha Pond Segment MA97-06

This segment is a 0.89 mi² Class SA tidal estuary. This segment extends from the mouth of Menemsha Creek to the confluence with Nashaquitsa Pond, Gay Head. The MADEP WQA lists no water withdrawals. The US Coast Guard-Meneshma has a NPDES permit authorizing the discharge of treated sanitary waste to Fresh Pond, which is located in the watershed of this segment. The Wampanoag Aquinnah Shellfish Hatchery discharges to this segment but is not required to obtain a permit, because the discharge is below the threshold for a permit. A boat pump out is operated by the Town of Chilmark on this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved (Figure 1-1).

4.3. The Elizabeth (Gosnold) Islands

Two impaired segments in the Elizabeth Islands are on Cuttyhunk Island, located in the southwestern tip of the island chain.

Westend Pond (Gosnold Pond) Segment MA97-20

This segment is a 0.10 mi² Class SA tidal estuary located on the southwestern corner of Cuttyhunk Island. The MADEP WQA lists no discharges or water withdrawals for this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Approved (Figure 1-1).

Cuttyhunk Pond Segment MA97-21

This segment is a 0.15 mi² Class SA tidal estuary located on the northeastern shore of Cuttyhunk Island. The segment consists of the waters to the western extent of the channel connecting Cuttyhunk Pond to Cuttyhunk Harbor. The MADEP WQA lists no discharges or water withdrawals for this segment.

Impairment status for this segment was based on DMF data. DMF shellfish growing area status as of July 2000: Conditionally Approved for 0.14 mi²; Prohibited for 0.01 mi² (Figure 1-1).

5.0 Potential Sources

The Islands watershed has 14 estuary segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. Sources of indicator bacteria in the Islands watershed are many and varied. Table 5-1 summarizes the estuaries impaired due to measured indicator bacteria densities and identifies some of the suspected and known sources identified in the MADEP WQA.

Some dry weather sources may include:

- leaking sewer pipes,
- storm water drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- recreational activities,
- wildlife, including birds, and
- illicit boat discharges.

Some wet weather sources may include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the Islands watershed, because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g. see Tables 5-2 and 5-3). This approach is suitable for the TMDL analysis, because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited, because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available from similar watersheds.

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the Islands Watershed.

Segment	Potential Sources
<i>Nantucket</i>	
Nantucket Harbor MA97-01	Unknown
Polpis Harbor MA97-26	Onsite treatment systems (septic systems) and wildlife other than waterfowl
Sesachacha Pond MA97-02	Unknown
<i>Martha's Vineyard</i>	
Vineyard Haven Harbor MA97-09	Unknown
Oak Bluffs Harbor MA97-07	Unknown
Sengekontacket Pond MA97-10	Unknown
Edgartown Harbor MA97-15	Unknown
Edgartown Great Pond MA97-17	Unknown
Oyster Pond MA97-13	Unknown
Tisbury Great Pond MA97-18	Unknown
Chilmark Pond MA97-05	Unknown
Menemsha Pond MA97-06	Unknown
<i>Gosnold Islands</i>	
Westend Pond MA97-20	Unknown
Cuttyhunk Pond MA97-21	Unknown

Source identified in the MADEP WQA.

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source, because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. The EPA, MWRA, the Boston Water and Sewer Commission (BWSC) and many communities throughout the Commonwealth have been active in the identification and mitigation of these sources. It is estimated by EPA New England that over one million gallons per day (gpd) of illicit discharges were removed in the last decade in the Charles River Watershed, for example. It is probable that illicit sewer connections exist in storm drainage systems serving the older developed portions of the Islands watershed.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. According to the MADEP WQA, “no towns in the Islands watershed are Phase II stormwater communities” (MADEP 2003a). Therefore, communities in the Islands watershed are not subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. However, illicit discharge detection is still a recommended action for Islands communities. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Islands watershed. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to bacterial impairment at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high and the flushing action of waves or tides is low.

Another potential source of pathogens is the discharge of sewage from vessels with onboard toilets. These vessels are required to have a marine sanitation device (MSD) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pump-out facility or discharged into the water more than 3 miles from shore. Uneducated boaters may discharge untreated sewage from these devices into near-shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage. Finally, even properly operating MSDs may discharge sewage in concentrations higher than allowed in ambient water for fishing or shellfishing. Vessels are most likely to contribute to bacterial impairment in situations where large numbers of vessels congregate in enclosed environments with low tidal flushing. Many marinas and popular anchorages are located in such environments.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. The land area of this watershed is made up of Dukes and Nantucket counties, which had a combined population of 24,507 as of 2000 (Cape Cod Times 2001). This translates to 2,450 dogs producing 1,225 pounds of feces each day. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor of pathogen pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading, because it is often unknown whether the sample is representative of the “true” mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler, which can proportion sample aliquots based on flow. Typical storm water event mean densities for various indicator bacteria in Massachusetts watersheds and nationwide are provided in Tables 5-2 and 5-3. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

Table 5-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS ¹	Reduction to Meet WQS (%)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 - 98.6)

¹ Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002b; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform ¹ Organisms / 100 mL	Class B WQS ²	Reduction to Meet WQS (%)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

¹ Derived from NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

² Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 14 segments within the Islands watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$\text{TMDL} = \text{WLAs} + \text{LAs} + \text{Margin of Safety}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in terms of a concentration because the water quality standard is also expressed in terms of the

concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$\text{TMDL} = \text{State Standard} = \text{WLA}_{(p1)} = \text{LA}_{(n1)} = \text{WLA}_{(p2)} = \text{etc.}$$

Where:

$\text{WLA}_{(p1)}$ = allowable concentration for point source category (1)

$\text{LA}_{(n1)}$ = allowable concentration for nonpoint source category (1)

$\text{WLA}_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class B and SA areas not designated for shellfishing (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For Class SA open shellfish area surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 43 organisms per 100 mL*.

For marine bathing beaches (BEACH Act standard) (1) *the geometric mean of a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period) shall not exceed 35 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 104 colonies per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL*.

Waste Load Allocations (WLAs) and Load Allocations (LAs).

There are several WWTPs and other NPDES-permitted wastewater discharges within the Islands watershed. NPDES wastewater discharge WLAs are set at the WQS. In addition there are storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class SA and B segments within the Islands watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from sanitary sewer overflows (SSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are several sets of WLAs and LAs, one for Class SA shellfish open waters, one for Class B and shellfish restricted Class SA waters, no discharge areas, freshwater beaches, and marine beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, including failing septic systems, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in Tables 5-2 and 5-3. These data indicate that up to two to three orders of magnitude (i.e. greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of the best management practices (BMPs), such as those associated with the Phase II control program in designated Urban Areas.

The expectation to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities.

This TMDL applies to the 14 pathogen impaired segments of the Islands watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Islands Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
B, SA	Illicit discharges to storm drains	0	N/A
B, SA	Leaking sanitary sewer lines	0	N/A
B, SA	Failing septic systems	N/A	0
B & Not Designated for Shellfishing SA	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ²	N/A
B & Not Designated for Shellfishing SA	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³	N/A
B & Not Designated for Shellfishing SA	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ²	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms ³
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) ¹	Load Allocation Indicator Bacteria (CFU/100 mL) ¹
Marine Beaches ⁴	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies
Fresh Water Beaches ⁵	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR <i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR <i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

¹ Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

² Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

³The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

⁴ Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

⁵ Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Islands watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to the Islands watershed waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs should be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the Islands watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the Islands watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, and failing septic systems, are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters, and tributary storm water drainage systems during both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. The MADEP, EPA, communities and local watershed organizations within the Islands watershed have been successful in carrying out such monitoring, identifying sources, and, in some cases, mobilizing the responsible municipality and other entities to begin to take corrective actions.

Storm water runoff represents another major source of pathogens in the Islands watershed, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the Islands watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The *“Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts”* was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with EPA and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/Local watershed conservation groups
Development of comprehensive storm water management programs including identification and implementation of BMPs	Islands Watershed Communities
Illicit discharge detection and elimination	Islands Watershed Communities and local watershed conservation groups
Leaking sewer pipes and sanitary sewer overflows	Islands Watershed Communities
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners, Islands Watershed Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, Islands Watershed Communities, and local watershed conservation groups
Organize and implement education and outreach program	Islands Watershed Communities
Write grant and loan funding proposals	MADEP, Islands Watershed Communities, and local watershed conservation groups
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP, Islands Watershed Communities, and local watershed conservation groups
Provide periodic status reports on implementation of remedial activities	MADEP, Islands Watershed Communities, and local watershed conservation groups

7.1. Summary of Activities within the Islands Watershed

There are several organizations on Nantucket and Martha's Vineyard concerned with improving water quality and conserving the islands' natural resources. Many of these organizations have already made strides towards monitoring and/or improving fecal coliform levels in their area's waterbodies.

The Nantucket Land Council focuses on preserving land, protecting water resources and working with the town to conduct ecologically sound planning. The Council is focused on protecting groundwater resources from pollution and has conducted water studies on pollutants. The Council works with the town to incorporate the study findings into their planning (NLC 2000).

Part of the duties of the Nantucket Harbormaster is monitoring water quality of all the waters of Nantucket, including Tuckernuck and Muskeget Islands. Part of the water quality monitoring includes sampling point source and runoff pollution points. The Harbormaster also educates people on and enforces the No-Discharge Areas law (See No Discharge Areas section 7.6) (CIHA 2005).

The Tisbury Waterways, Inc. (TWI) is concerned with water issues relating to the waterways in their town, which includes Vineyard Haven Harbor. The organization helps people seeking grant money for water research, conducts conservation projects, and works with other organizations to conduct long-term environmental planning (TWI 2004).

The Lagoon Pond Association, Inc. (LPA) strives to preserve Lagoon Pond and adjacent areas and waters. LPA attempts to preserve the waterbody's resources and to cooperate with governmental agencies to solve environmental issues. The LPA also funds water quality monitoring for Lagoon Pond (MVDC 2004).

The Great Pond Foundation (GPF) seeks to promote the health of the Edgartown Great Pond. The Foundation's mission is twofold: to educate people on the pond's state and value and to work with the Town of Edgartown to preserve the pond's ability to support recreation and remain ecologically sound. GPF is also dedicated to providing grants for research relevant to their mission (GPF 2003).

The Wampanoag Tribe of Gay Head (Aquinnah) conducted a water quality investigation. The investigation included pathogens and was completed in 1995. The tribe plans to create a Tribal water quality laboratory to test for coliforms bacteria. The Tribe has also trained members on the collection and analysis of water quality samples (Wampanoag Tribe of Gay Head 1999-2003).

The Friends of Sengekontacket, Inc (FOS) aims to preserve the resources of Sengekontacket Pond. FOS's goals are to protect the area's water quality and wildlife habitat and to promote sound management. Some of the FOS's focus areas are research, outreach education programs, and establishing alliances with residents and government to protect the pond (FOS 2004).

The Woods Hole Oceanographic Institution (WHOI) has conducted studies on Martha's Vineyard's waters. The Edgartown Harbor Association provided \$750,000 to fund a water quality study conducted by WHOI. FOS has also funded WHOI studies totaling more than \$90,000 (Karney 2005).

Several other organizations on Martha's Vineyard are concerned with water quality including Protect Our Water, Squibnocket Pond District Advisory Committee, the Martha's Vineyard Commission, The Riparian Owners of Tisbury Great Pond, The Senior Environmental Corps, The Vineyard Conservation Society, and the Vineyard Research Institute (VCS 2005). More information can be found on these organizations on the Vineyard Conservation Society website: <http://almanac.vineyardconservationsociety.org/groups/groupsview.php>.

The Martha's Vineyard Action Plan is being developed. The Watershed Team responsible for putting together the Martha's Vineyard Watershed Assessment and Action Plan is looking for input from local governments and citizen organizations. When complete, the plan will give guidance to local governments and concerned organizations on water quality protection and improvement (VCS 2002).

Data supporting this TMDL indicate that indicator bacteria enter the Islands waters from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The *"Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts"* provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Illicit Sewer Connections and Failing Infrastructure

Elimination of illicit sewer connections and repairing failing infrastructure are of extreme importance. According the United States Census Bureau there are no "Urban Areas" in the Islands watershed and therefore, there are no Phase II communities regulated under the NPDES program requiring an Illicit Detection and Elimination component. However, the Oaks Bluffs Board of Health has adopted "Stormwater Management Regulations" with the goal of storm water pollution prevention and illicit connection elimination (MADEP 2003a). Implementation of these regulations will thus help communities achieve bacteria TMDLs.

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004c) for the Lower Charles River. The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Although originally prepared for the Charles River watershed it is applicable to all watersheds throughout the Commonwealth. A copy of the guidance document is provided in Appendix A.

7.3. Storm Water Runoff

Storm water runoff can be categorized in two forms 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP), which must employ and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination.

The Town of Tisbury instituted control measures for storm water entering Lake Tashmoo and causing shellfish closures. Tisbury Waterways, Inc. and the town installed a series of 12 “first flush” leaching basins along road drains. The basins receive the first ¼” of rainfall (containing most of the contaminants) and provide sufficient residence time for fecal coliform to oxidize and decay. Results of water quality samples in Lake Tashmoo after the installation of the leaching basins showed a 91% reduction in fecal coliform and a 98% reduction in total coliform (USEPA 2002).

Also, the Towns of Tisbury and Oak Bluffs and the Martha’s Vineyard Commission mapped storm drains in the two towns. The mapping will be used for engineering projects to fix storm water problems in each town (MVC 2004a).

7.4. Failing Septic Systems

Bacteria contributions from septic systems could potentially be significant given that on Martha’s Vineyard 80% of the roughly 1500 dwellings are serviced by on-site wastewater disposal systems (MVC 2004b). Septic system bacteria contributions to the Islands watershed may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before transfer of property ownership, building expansions, or changes in use of properties, will aid in the discovery of poorly

operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at <http://www.mass.gov/dep/brp/www/t5pubs.htm>. Locally, the Martha's Vineyard Commission has developed an informational guide on the importance of properly operated septic systems. This report is available on the worldwide web at <http://mvcommission.actwin.com/planning/water.html>.

7.5. Wastewater Treatment Plants

There are five WWTPs in the Islands watershed. WWTP discharges are regulated under the NPDES program when the effluent is released to surface waters. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the following website: www.epa.gov/region1/npdes/permits_listing_ma.html. Groundwater permits are available at <http://www.mass.gov/dep/brp/gw/gwhome.htm>.

7.6. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty. Options for controlling pathogen contamination from boats include:

- petitioning the State for the designation of a No Discharge Area (NDA);
- supporting installation of pump-out facilities for boat sewage;
- educating boat owners on the proper operation and maintenance of marine sanitation devices (MSDs); and
- encouraging marina owners to provide clean and safe onshore restrooms and pump-out facilities.

Nantucket Harbor has already been established as a no discharge area (NDA). This designation by the Commonwealth of Massachusetts and approved by the EPA provides protection of this area by a Federal Law which prohibits the release of raw or treated sewage from vessels into navigable waters of the U.S. The law is enforced by the Massachusetts Environmental Police. The MACZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to State regulations allowing for the institution of fines up to \$2000 for violations within a NDA (USEPA 2004a). Additional NDAs could be established increasing the number and size of protected areas.

7.7. Funding/Community Resources

A complete list of funding sources for implementation of non-point source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at <http://www.mass.gov/dep/brp/wm/nonpoint.htm>. This list includes specific programs available for non-point source management and resources available for communities to manage local growth and development. The State Revolving Fund (SRF) provides low interest

loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.8. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the Islands watershed includes several components:

1. continue with the current monitoring of the Islands watershed,
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. monitor areas where BMPs and other control strategies have been implemented or discharges have been removed to assess the effectiveness of the modification or elimination,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions;
- establishing sampling locations in an effort to pin-point sources;
- researching new and proven technologies for separating human from animal bacteria sources; and
- assessing efficacy of BMPs.

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later....

11.0 References

- Ayres Associates 1993. Onsite Sewage Disposal Systems Research in Florida. The Capacity of Fine Sandy Soil for Septic Tank Effluent Treatment: A Field Investigation at an In-Situ Lysimeter Facility in Florida.
- Cape Cod Times 2001. Census 2000: County population ranked by change. Information from website, downloaded March 2005.
<http://www.capecodonline.com/special/census/countypoprank.htm>
- Center for Watershed Protection 1999. Watershed Protection Techniques. Vol. 3, No. 1.
- CIHA 2005. Town of Nantucket. Cape & Islands Harbormasters Association. Information from website, downloaded March 2005. <http://www.vsv.cape.com/~harharb/ciha/nantucket.html>.
- DMF 2002. Massachusetts Division of Marine Fisheries. Programs and Projects. Shellfish Sanitation and Management. Information from website, downloaded March 2005.
<http://www.mass.gov/dfwele/dmf/programsandprojects/shellsani.htm>
- EOEA 2003a. Island of Martha's Vineyard Watershed. Executive Office of Environmental Affairs. Information from website, downloaded March 2005.
<http://www.mass.gov/envir/water/marthasVineyard/marthasVineyard.htm>
- EOEA 2003b. Island of Nantucket Watershed. Executive Office of Environmental Affairs. Information from website, downloaded March 2005.
<http://www.mass.gov/envir/water/nantucket/nantucket.htm>
- FOS 2004. About the Friends of Sengekontacket, Inc. Friends of Sengekontacket, Inc Information from website, downloaded March 2005. <http://www.sengekontacket.org/home.html>
- GPF 2003. Great Pond Foundation: Welcome. Great Pond Foundation. Information from website, downloaded March 2005. <http://greatpondfoundation.org>
- Karney, R. C. 2005. Poor water quality? Not in my backyard! The effectiveness of neighborhood pond associations in the protection and improvement of shellfish growing waters on Martha's Vineyard. Martha's Vineyard Shellfish Group, Inc. Information from website, downloaded March 2005. <http://www.mvshellfishgroup.org/Reports/Water.htm>
- MADEP 2000a. 314 CMR 4.00: Massachusetts Surface Water Quality Standards. Massachusetts Department of Environmental Protection Bureau of Waste Prevention. Available for download at <http://www.mass.gov/dep/bwp/iww/files/314cmr4.htm>

- MADEP 2000b. Nonpoint Source Management Plan Volume I Strategic Summary. Massachusetts Department of Environmental Protection Bureau of Waste Prevention. Available for download at <http://www.mass.gov/dep/brp/wm/nonpoint.htm>
- MADEP 2002a. Cape Cod Watershed Water Quality Assessment Report. Massachusetts Department of Environmental Protection, Division of Water Management. Worcester, Massachusetts. Available for download at <http://www.mass.gov/dep/brp/wm/wqassess.htm>
- MADEP 2002b. Final Total Maximum Daily Loads of Bacteria for Neponset River Basin. Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Division of Watershed Management. Report MA73-01-2002 CN 121.0. Boston, Massachusetts. Available for download at <http://www.mass.gov/dep/brp/wm/tmdls.htm>
- MADEP 2003a. Islands Watershed 2000 Water Quality Assessment Report. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, Massachusetts. Available for download at <http://www.mass.gov/dep/brp/wm/wqassess.htm>
- MADEP 2003b. Massachusetts Year 2002 Integrated List of Waters. Part 2 – Final Listing of Individual Categories of Waters. Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Division of Watershed Management. Boston, Massachusetts. Available for download at <http://www.mass.gov/dep/brp/wm/tmdls.htm>.
- MassGIS 2005. Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs. MADEP 2002 Integrated List of Waters (305(b)/303(d)) as of 2005; Land Use as of 1999; Town Boundaries as of 2002. Census TIGER Roads as of 2003. Major Drainage Boundaries as of 2003. Designated Shellfish Growing Area as of July 2000. Downloaded January 2005. <http://www.mass.gov/mgis/laylist.htm>
- MDC-CDM. 1997. Wachusett Stormwater Study. Massachusetts District Commission and Camp, Dresser, and McKee, Inc.
- Metcalf and Eddy 1991. Wastewater Engineering: Treatment, Disposal, Reuse. Third Edition.
- Metcalf and Eddy 1992. Casco Bay Storm Water Management Project.
- MVC 2004a. Current Planning Projects. Martha's Vineyard Commission. Information from website, downloaded March 2005. <http://mvcommission.actwin.com/planning/surrent.html>
- MVC 2004b. Wastewater and the Environment. Martha's Vineyard Commission Information from website, downloaded March 2005. <http://www.mvcommission.org/planning/water.html>
- MVDC 2004. Lagoon Pond Association, Inc. (LPA). Martha's Vineyard Donors Collaborative. Information from website, downloaded March 2005. <http://www.mvdonors.org/page54.html>

- NLC 2000. Safeguarding Nantucket's Natural Resources. Nantucket Land Council. Information from website, downloaded March 2005. <http://www.nantucketlandcouncil.org/mission.html>
- TWI 2004. Tisbury Waterways, Inc. Information from website, downloaded March 2005. <http://www.tisburywaterways.org>
- USEPA 1983. Results of the Nationwide Urban Runoff Program. Volume I. Final Report. Water Planning Division. Washington, D.C. 159 pp.
- USEPA 1986. Ambient Water Quality Criteria for Bacteria – 1986. USEPA 440/5-84-002.
- USEPA 1997. Urbanization of Streams: Studies of Hydrologic Impacts. USEPA 841-R-97-009
- USEPA 1999. Regional Guidance on Submittal Requirements for Lake and Reservoir Nutrient TMDLs. USEPA, New England Region. November 1999.
- USEPA 2001. Protocol for Developing Pathogen TMDLs. EPA 841-R-00-002
- USEPA 2002. Section 319 success stories, Vol. III: Massachusetts. Information from website, downloaded March 2005. <http://www.epa.gov/owow/nps/Section319III/MA.htm>
- USEPA 2004a. No Discharge Areas in Massachusetts. Information from website, downloaded March 2005. <http://www.epa.gov/region01/eco/nodiscrg/ma.html>
- USEPA 2004b. Monitoring and Assessing Water Quality. Information from website, downloaded December 2004. <http://www.epa.gov/OWOW/monitoring/volunteer/stream/vms511.html>
- USEPA 2004c. Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol Guidance for Consideration - November 2004 United States Environmental Protection Agency Region I New England
- USEPA 2005. Sole Source Aquifer Protection Program. Information from website, downloaded March 2005. <http://www.epa.gov/safewater/ssanp.html>
- USGS 2002. Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 199-September 2000. 02-4129. United States Geological Survey. Northborough, Massachusetts.
- VCS 2002. Introducing the Martha's Vineyard Watershed Action Plan. Vineyard Conservation Society. Information from website, downloaded March 2005. <http://almanac.vineyardconservationsociety.org/government/state.html>
- VCS 2005. Community Groups. Vineyard Conservation Society. Information from website, downloaded March 2005. <http://almanac.vineyardconservationsociety.org/groups/groupsview.php>

Wampanoag Tribe of Gay Head 1999-2003. Water Quality. Wampanoag Tribe of Gay Head (Aquinnah Information from website, downloaded March 2005.
<http://www.wampanoagtribe.net/resource/water.htm>

Appendix A

Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol
Guidance for Consideration - November 2004